REMARKS

Please reconsider the application in view of the above amendments and the following remarks. Applicant thanks the Examiner for carefully considering this application

Disposition of Claims

Claims 2-9, 11-23, 25-38, 40, 45, and 46 are pending in this application. Claims 45 and 46 are independent. The remaining claims depend, directly or indirectly, from claims 45 and 46.

Claim Amendments

Independent claims 45 and 46 have been amended to clarify the invention recited. Claims 11-13 have been amended to correct antecedent basis. Claim 25 has been cancelled, as its limitations were previously incorporated into claim 46. Support for these amendments may be found, for example, in the Specification, paragraphs [0042]-[0045]. No new matter has been added by these amendments.

Applicant notes the Examiner's remark in the Office Action dated September 9, 2008 (hereinafter "the Action"), that Claims 11-13 were understood to have been cancelled previously, as they depend on cancelled claim 10. However, Applicant asserts that claims 11-13 were inadvertently not amended to update their dependency. Claims 11-13 have been amended in this reply to correct antecedent basis.

Drawings

Please amend the figures as shown in the enclosed replacement sheets. The attached sheet(s) of drawings includes changes to Figure 6. As originally filed, Figure 6 was

correct; however in subsequent paperwork, Figure 6 was mistakenly replaced with a duplicate of Figure 5. The Replacement Sheet, attached, amends Figure 6 to correspond with originally filed Figure 6. Applicant submits that these replacement figures are formal and no new matter is added by these amendments.

Rejections under 35 U.S.C. § 112

Claims 2-9, 14-23, 25-38, 40, and 45-46 stand rejected under 35 U.S.C. § 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention. Specifically, the Examiner asserts that amended claims 45 and 46 disclose limitations that evaluate, compare, and generate a ratio, but the ratio is not used in the subsequent steps of adjustment or outputting.

Claims 45 and 46 have been amended to clarify the use of the ratio in the steps of adjustment and outputting. Specifically, claim 45, as amended, recites in part adjusting at least one parameter of the selected drill bit based on the generated ratio; and outputting a drill bit design based on the generated ratio and the adjusting. Claim 46, as amended, recites in part adjusting at least one parameter of the bottom hole assembly based on the generated ratio; and outputting a bottom hole assembly based on the generated ratio and the adjusting. As such, Applicant asserts amended claims 45 and 46 are definite. Claims dependent on claims 45 and 46 are likewise definite. Therefore, Applicant respectfully requests withdrawal of the 35 U.S.C. § 112 rejection of claims 2-9, 14-23, 25-38, 40, and 45-46.

Rejections under 35 U.S.C. § 103

A. Claims 2-9, 14-23, 25-38, 40, and 45-46 are rejected under 35 U.S.C. § 103(a) as being unpatentable over "The Operational Mechanics of The Rock Bit," by Ma, *et al.*

(hereinafter "Ma"), further in view of U.S. Patent No. 6,695,073, issued to Glass, *et al.* (hereinafter "Glass"). Claims 2-9 and 11-23 depend, directly or indirectly, from independent claim 45. Claims 25-38 and 40 depend, directly or indirectly, from independent claim 46. Claims 45 and 46 have been amended in this reply. To the extent that this rejection may apply to the amended claims, the rejection is respectfully traversed.

As amended, independent claims 45 and 46 require, in part, determining radial forces acting on a selected drill bit (or a bottom hole assembly that includes a drill bit) during simulated drilling; summing magnitudes of the radial forces with respect to a direction to generate a sum of the radial forces; comparing the sum of the radial forces to an applied weight on bit; generating a ratio between the sum of the radial forces and the applied weight on bit; adjusting at least one parameter of the selected drill bit (or bottom hole assembly) based on the generated ratio; and outputting a drill bit (or bottom hole assembly) design based on the generated ratio and the adjusting.

For example, dependent claims recite a ratio of 0.20, *i.e.*, the resultant radial force is less than or equal to twenty percent of the applied weight on bit (WOB). In other words, at any given time during drilling the resultant radial force should not exceed 20% of the WOB. Bit performance may be improved as a ratio of the resultant radial force to an applied weight on bit is minimized. Thus, in one embodiment of the present invention, the resultant radial force is less than or equal to 10% of the WOB, and more preferably, the resultant radial force is less than or equal to 5% of the WOB.

Initially, Applicant notes that embodiments of the present invention may be used advantageously to minimize radial force imbalance that may result in a whirl effect and reduce cutting efficiency of a drill bit. Embodiments of the present invention may increase the life of a

bit by preventing damage due to repetitive impact of the cutting structure against the walls of the wellbore during drilling. Also, embodiments of the present invention may be adapted for use with any simulation method that can be adapted to output radial force data determined during a simulation.

In regards to Ma, Ma relates to the kinematics of a roller cone bit, but does show or suggest summing magnitudes of the radial forces with respect to a direction to generate a sum of the radial forces; comparing the sum of the radial forces to an applied weight on bit; generating a ratio between the sum of the radial forces and the applied weight on bit; adjusting at least one parameter of the selected drill bit (or bottom hole assembly) based on the generated ratio; or outputting a drill bit (or bottom hole assembly) design based on the generated ratio and the adjusting, as required by claims 45 and 46. In fact, while Ma discloses various force determinations, Ma does not specifically disclose or suggest evaluating a bit structure on the basis of radial force, much less on the basis of a *ratio of radial force to applied weight on bit*, as admitted by the Examiner. The Examiner relies on Glass to teach that which Ma lacks.

Glass teaches a method for designing a bit that involves balancing forces and torques acting on cutters while a bit is drilling through a transitional section between soft and hard rock formations. Specifically, Glass discloses optimizing a fixed-cutter drill bit so that cutter forces and torques are evenly distributed not only during drilling of homogeneous rock, but also in transitional formations. *See* Glass, Abstract. Glass does not teach adjusting design parameters <u>based on a ratio</u> between radial forces and weight on bit to obtain a design.

Applicant further notes that Glass teaches summing cutter forces to the orthogonal components of the force system required to drill at the input parameters. The orthogonal components are summed at the origin of the bit coordinate system. *See* Glass, col. 4,

lines 30-33 and col. 4, lines 35-36. These calculations are an output that may be generated once per revolution as a percentage of weight on bit or torque on bit. *See* Glass, col. 4, lines 53-55. Glass does not disclose using these calculations as anything other than data output. In fact, Glass exclusively teaches balancing cutter loads. *See*, for example, Glass, Abstract, col. 5, lines 61-64, and Claims 1 and 3.

In contrast, claims 45 and 46 of the present invention require, in part, generating a ratio between the sum of the radial forces and the applied weight on bit and adjusting at least one parameter of the selected drill bit (or bottom hole assembly) <u>based on the generated ratio</u> to output a design. Thus, there are several fundamental differences between the present invention and Glass.

As described in the present Specification at paragraph [0004], imbalances between radial forces may cause a rock bit to gyrate (*i.e.*, "whirl"). For example, roller cones independently rotate about an axis oblique to the axis of the bit body. Due to this orientation, a conventional rock bit may experience unbalanced lateral forces (radial forces) that cause the rock bit to gyrate or laterally bounce around the bottomhole and impact the wellbore during drilling, a motion commonly known as gyration, or "whirling." Bit whirling is an undesirable performance characteristic, because it results in inefficient drilling of the bottomhole and can potentially damage the bit prematurely. Therefore, analysis of radial forces acting on the bit (*i.e.*, as a ratio to weight on bit) allow improvements in design, which may include reduced bit whirl (*see* Specification, paragraph [0005]-[0006]). These design improvements may not possible by simply <u>equalizing cutter forces or torques</u>, as taught by Glass. Glass fails to show or suggest adjusting design parameters based on a ratio between radial forces and applied weight on bit, as required by amended independent claims 45 and 46.

To visualize the difference between the present disclosure and Glass, Applicant offers Figure 5 and amended Figure 6, attached, as an example. Figures 5 and 6 show chart plots of distributions of ratios of resultant radial forces to applied weights on bit. Each chart plot enumerates the occurrences of a ratio of the resultant radial force to the applied weight on bit. The frequency of occurrences in each chart plot is presented on the Y-axis as percentages of total drilling time. The ratios between the resultant radial force and the applied weight on bit are presented on the X-axis in decimal form, *i.e.*, fractions of the radial force to the applied weight on bit. Figure 6 may be considered to show improvements in bit performance relative to Figure 5, however Applicant points out that the ratios of radial force to weight on bit are not equalized in Figure 6. In contrast, Glass teaches equalizing cutter forces and torques. For example, Glass teaches that the forces which appear on the individual cutting elements of a drill bit should be evenly distributed, as far as possible, under transitional conditions as well as under steady-state conditions. *See* Glass, col. 2, lines 52-55.

As indicated in the present specification and exemplified by Figure 6, a drill bit may be purposefully designed to produce an imbalanced bit, where radial forces (or ratios of radial forces to weight on bit) are not equal, such as in a particular direction, for example, to obtain a design for a bit having a particular "walking" tendency. Examples of bit design parameters that may be adjusted include, but are not limited to, an arrangement of cutting elements on a drill bit (which may be within a row or between rows), a number of cutting elements on a drill bit, and a geometry of cutting elements on a drill bit, or orientation of cutting elements. Embodiments of the present specification advantageously use the ratio of radial forces to weight on bit to obtain an improved design.

As stated above, Ma and Glass, whether considered separately or in combination, do not teach, show, or suggest the present limitation of determining a ratio of radial force to applied weight on bit, to evaluate bit performance as required by amended independent claims 45 and 46. Thus, claims 45 and 46, as amended, are patentable over Ma and Glass. Dependent claims are allowable for at least the same reasons.

B. Claims 8 and 9 are rejected under 35 U.S.C. § 103(a) as being unpatentable over Ma and Glass further in view of "Drag-Bit Performance Modeling," by Warren *et al.* (hereinafter "Warren"). Claims 8 and 9 depend, directly or indirectly, from independent claim 45. As described above, claim 45 has been amended in this reply and is patentable over Ma and Glass.

Warren discloses modeling polycrystalline-diamond-compact (PDC) bit designs and modeling the forces required to remove a fixed volume of rock with a single cutter applied to different PDC bit designs. Warren further discloses results of comparing such models to laboratory drilling tests for different bit designs in different rocks to determine whether the model predictions are comparable to the measured data. Warren fails to disclose that which Ma and Glass lack. Specifically, Warren does not teach, show, or suggest the present limitation of determining a ratio of radial force to applied weight on bit, to evaluate bit performance as required by amended independent claim 45. Therefore, independent claim 45, as amended, is patentable over Ma, Glass, and Warren, considered separately or in combination. Dependent claims are allowable for at least the same reasons. Thus, claims 8 and 9 are patentable for at least the same reasons.

Applicant believes this reply is fully responsive to all outstanding issues and places this application in condition for allowance. If this belief is incorrect, or other issues arise,

the Examiner is encouraged to contact the undersigned or his associates at the telephone number listed below. Please apply any charges not covered, or any credits, to Deposit Account 50-0591 (Reference Number 05516/148002).

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Respectfully submitted,

By_______________

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Attachments